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Lidar observations of cirrus clouds in Palau (7°33′ N, 134°48′ E)

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Abstract. An analysis of the depolarization vs temperature dependence, as well as the vertical profile of backscattering inside clouds and the relationship of LR with optical thickness, depolarization and temperatures is presented.

1 Distribution of depolarization vs temperature

Figure S1 reports the trend of particle depolarization with decreasing temperature, It shows a compact linear relationship, with a progressive increase of particle depolarization from 40% to 60% as temperature gets colder. Noticeable, in the range 200-190K, the presence of low depolarizing clouds, a behaviour that deviates from the main trend, with the probability of observing low values of depolarization which seems to increase as temperature decreases.

2 Geometrical vs optical midcloud altitude

Figure S2 reports the relative difference between the geometrical and optical mid cloud altitude (z_g-z_o)/z_g, vs altitude, colour coded with τ. Positive values indicate that the backscattering is more intense in the upper part of the cloud, which is then radiatively more effective than the lower part. This parameter may vary depending on the distribution of Ice Water Content (IWC) inside the cloud, in turn affected by the microphysics of particle formation and redistribution by sedimentation and evaporation. In our case, the lower and upper parts of the cirrus appear to produce the same scattering effect for small to medium values of τ, indicative of an even distribution of backscatter inside, which we may take as a proxy for the distribution of IWC. Conversely, the thickest clouds tend to have lower backscatter in their bottom part with respect to the top part, with few exceptions for the highest ones; this is arguably due to mass redistribution by sedimentation and subsequent evaporation.

3 Lidar Ratio behaviour

The analysis of the LR may add another piece of information, as it is a parameter that may be linked to the average size dimension of the particles: the lower the LR, the larger the particles. However this analysis is tentative and reported only for completeness, and do not stand on solid grounds, as the LR is not directly measured by our instrument.

In figure S3 we report the occurrence of LR vs τ. Although disperse, LR stays around the value of 29 sr, often measured and reported in literature. The dispersion of LR around that value tends to increase for thin clouds, larger values of LR tends to appear. This may be indicative of a reduced reliability of the inversion process, or, albeit speculative, the presence of smaller particles in the thinner clouds. Looking at the histogram of occurrence of LR and depolarization, shown in figure S4, we see again LR values around 29 sr, with a trend that seems to suggest an increase in the LR as the depolarization decreases. In figure S5 LR is reported in relation to the cloud temperature: no clear behaviour can be discerned.

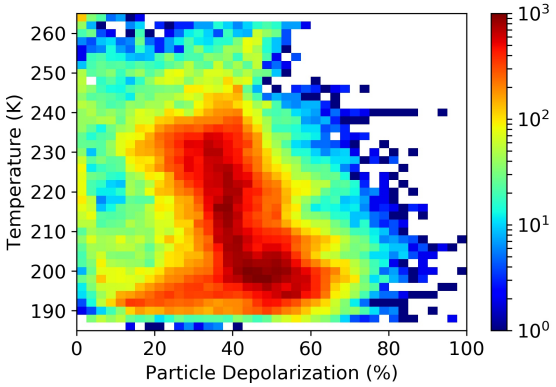

Figure S1. Distribution of particle depolarization vs temperature. Data are 10 min averages of lidar vertical profiles, with 30 m vertical resolution. The colour codes the number of samples in each bin. Only data with BR>1.2 have been reported.

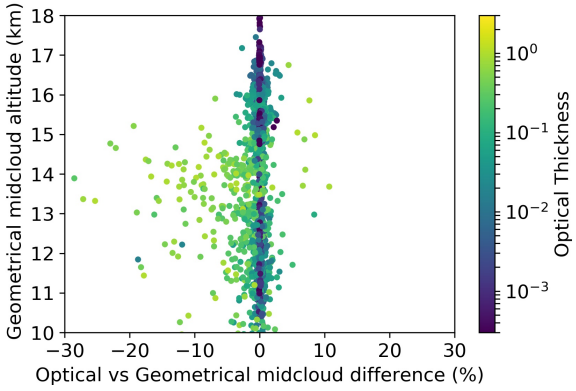

Figure S2. Scatterplot of the relative difference between the optical and geometrical midcloud altitude, vs the geometrical mid cloud altitude, colour coded with the cloud optical thickness.

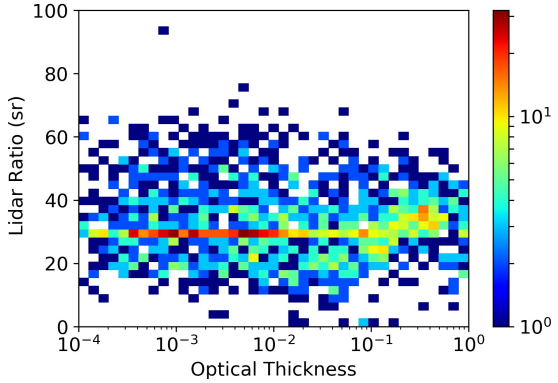

Figure S3. Distribution of Lidar Ratio (LR) vs optical thickness. The thick black line reports the optical thickness threshold value for SVC. The observations that accumulate along the line at LR=29 sr are those for which the inversion did not produce convergence to a result for LR. For these observation, LR was set at 29 sr by default.

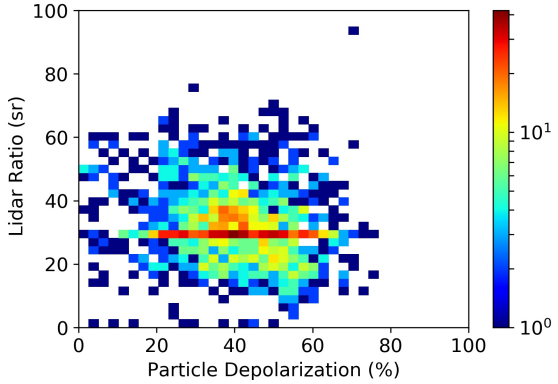

Figure S4. Distribution of Lidar Ratio (LR) vs Particle Depolarization. The observations that accumulate along the line at LR=29 sr are those for which the inversion did not produce convergence to a result for LR. For these observation, LR was set at 29 sr by default.

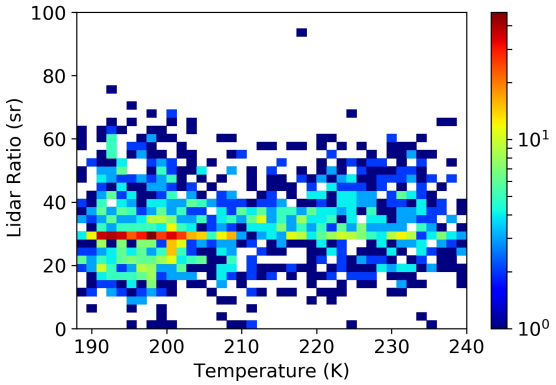

Figure S5. Distribution of Lidar Ratio (LR) vs mid cloud Temperature. The observations that accumulate along the line at LR=29 sr are those for which the inversion did not produce convergence to a result for LR. For these observation, LR was set at 29 sr by default.